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The role of repetition in free recall

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THE ROLE OF REPETITION IN FREE RECALL

by

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ABSTRACT

Three experiments investigated the hypothetical processes of organization and frequency, which have been advanced to explain the repetition effect in multi-trial free recall learning. Each experiment examined recall over a series of trials under conditions assumed to be conducive either to increments due to organization or increments due to frequency.

The results of experiment I indicated that recall of 9 critical words over 4 trials was independent of the number of words repeated with this critical set on each of the trials. According to the organizational hypothesis, the fewer the number of words repeated with the critical set on each trial, the greater would be the difficulty in organization of the critical set into higher order memory units. The fact that there was no difference in recall of the critical set argues in favour of a frequency hypothesis.

In experiments II and III, Ss received successive lists on which either all words were repeated, only recalled words were repeated, or only unrecalled words were repeated. Ss having only recalled words repeated did not differ in learning rate from Ss having all words repeated. These data suggest that frequency is not necessary for recall increments.

It was concluded that neither frequency nor organization alone are sufficient to explain the repetition effect. It was further suggested that recall increments result from more complex underlying processes than indicated by these theories.

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INTRODUCTION

Ebbinghaus (1885) first studied the effect of repetition on recall performance. The repetition effect has since become well known and universally accepted in verbal learning. However, the processes responsible are not as well understood as the effect itself. Two major theoretical positions, namely frequency and organization, attempt to account for the repetition effect. The present experiments attempt to clarify the relative contribution of both these processes in determining recall increments in multi-trial free recall learning.

Simply stated, the frequency hypothesis attributes the repetition effect to increases in the recall strength of each item independent of other items. The recall strength of each item is assumed to accumulate through the sheer frequency with which that item is presented (Asch and Ebenholtz,1962; Slamecka, 1968). On the other hand, the organizational hypothesis attributes the effect to the fact that repetition allows organization of material into easily recallable units (S-units). S-units imply that item storage is dependent in nature, in that each item influences recall of others within the same S-unit. This organizational process accompanying repetition aids in overcoming a limited retrieval memory system (Tulving, 1962;1964).

The Frequency Hypothesis

The frequency hypothesis has been the more traditional approach to the repetition effect. It originates from the typical incremental approach to learning phenomena in general. This approach has been

dominant in all areas of learning psychology, from paired-associate learning in humans to maze learning in rats. Its basic premise is that each trial of a learning situation strengthens the probability of a correct response. In free recall learning, this means that the recall strength of each item (probability of recall) increases with each repetition of that item, independent of other factors.

Several hypothetical processes have been postulated to account for increases in recall strength of each item, such as trace strengthening and multiple traces. However, the present investigation is concerned only with the assumption that the frequency of occurrence is sufficient to explain the increments in recall probability of repeated items.

There is no direct evidence to suggest that frequency increases the recall strength of each item, although this position is indirectly supported by the incremental form of the typical learning curve. However, the incremental appearence of the learning curve does not necessarily indicate increments in the recall strength of each item. For example, in paired-associate learning it had been assumed that frequency was sufficient to explain the learning curve. However, Rock (1957) demonstrated that associations may be formed in an all-or-none manner. Rock found that Ss receiving only correctly recalled pairs, with novel pairs substituted for the incorrect ones, learned a paired-associate list in the same number of trials as Ss who received the typical study and test trial procedure on the same list. This evidence suggested that in paired-associate learning, frequency

does not have a direct facilitative effect on the probability of association formation.

The Organizational Hypothesis

The basic assumption of an organizational hypothesis is that repetition produces increments in recall through allowing organization of the material to proceed. Organization refers to the development of higher order memory units. Tulving (1962) found that Ss grouped two or more items into related units to facilitate information retrieval. These higher order memory units have been termed "subjective units" (S-units), since Ss organize the words into larger units, even when the E does not impose any particular organization on the material, either in selection or recall instructions.

The organizational hypothesis assumes that organization facilitates information retrieval by allowing the S to overcome the constraints of a limited retrieval memory system. Tulving and Pearlstone (1966) have provided evidence which suggests that the memory system has a limited retrieval capacity. They used a cued recall procedure in which Ss were presented lists of words belonging to explicitly designated conceptual categories. Immediate recall in presence of category names as retrieval cues was significantly greater than non cued recall. This result has been verified by other investigations (Earhard, 1967; Tulving and Osler, 1968). Tulving and Pearlstone suggested that specific information about many words must be available in storage, in a form sufficient for their reproduction, even when this information is not accessible under a given set of recall conditions.

Tulving and his associates have conducted experiments designed to clarify the nature of the organizational hypothesis. They have presented data which suggested that the number of S-units retrieved is independent of the size of these S-units (Tulving and Patterson, 1968). Experimental Ss received a list which contained four closely related words (R words). Control Ss received a list of unrelated words (U words). Ss were given credit for recall of a functional unit when they recalled at leats one R word or one U word. For example, an S who recalled three R words and five U words received credit for the recall of six functional units. The mean number of functional units recalled was the same for experimental and control Ss. Thus, they concluded that the number of functional units recalled is independent of the size of the units. Also, Tulving and Osler (1967) have suggested that an S-unit functions as a unit in recall, in the sense that all or none of its constituent items are retrieved by an S.

An organizational hypothesis can then be summarized in the following way. The hypothesis holds that recall of a list word is greatly influenced by the recall or non-recall of other words within the same S-unit, although it may be independent of recall or non-recall of specific words outside the S-unit of which it is a member. Thus, retrieval of an item implies retrieval of all items within the same S-unit. Also, increasing the size of the S-units does not influence the number that can be recalled. Therefore, given the constraints of a limited retrieval memory, organization, through repetition, increases the information load which this limited retrieval capacity can convey.

Interpretation of Experimental Data

Tulving (1962;1964) observed that Ss do not recall items in a random fashion but rather recall groups of items. He developed a measure of this sequential organization in recall. This measure consisted of counting how frequently two items appeared adjacent in recall, separated by one other item, separated by two other items, and so on. This count was then analyzed to see if it deviated significantly from chance. Ss were consistently found to organize at a level statistically higher than the chance level.

There is additional evidence which favours an organizational hypothesis. Murdock and Babick (1961) have demonstrated that in free recall, repetition of a single item on successive lists did not increase the probability of recalling that item. This suggested that the frequency of occurrence of the repeated item was not sufficient to increase its recall strength. Also, Tulving (1966) found that mere repetition was not always sufficient to increase recall. In two studies, he had Ss read words, a number of times, as they appeared in a memory drum. They then learned a list composed of the words just seen, or completely novel words. No differences in recall were found between Ss during the list learning phase of the experiment. Tulving concluded that repetition is effective in permitting increased recall only when it leads to the formation of S-units.

In two additional experiments (Tulving, 1966), part-to-whole transfer was used to evaluate an organizational hypothesis. In this

procedure, Ss are given prior acquaintance with a list of words, by allowing them a number of study and recall trials. They are then transferred to a second list composed of these items and an equal number of novel items (experimental group), or of completely novel items (control group). If repetition alone is sufficient to increase recall, experimental Ss should show positive transfer on second list learning. However, experimental Ss showed no positive transfer and even slight negative transfer. These results have been confirmed by other investigators (Novinski,1969; Bower and Lesgold,1969). Tulving concluded that organization developed during practice on the first list was inappropriate to second list learning and that Ss were reluctant to alter this organization.

Similar results have been obtained using the whole-to-part transfer paradigm. In this procedure, Ss learn a larger list and are then transferred to a shorter list composed of randomly selected items from the larger list (experimental group), or completely novel items (control group). Again experimental Ss showed no positive transfer and even slight negative transfer. Again the results were interpreted in terms of inappropriate S-units formed during practice on the first list.

The organizational interpretation of part-to-whole and whole-to-part effects has been further strengthened by other types of studies (Bower and Lesgold, 1969; Bower, Lesgold and Tieman,1969). These investigators have demonstrated that if E induces experimental Ss to organize the first list in a manner which is appropriate to second list learning, then positive transfer is observed. The E induced Ss to

form appropriate S-units by giving imagery instructions during second list learning, which were either consistent or inconsistent with those given during first list learning.

In summary a great deal of evidence appears to support an organizational hypothesis. However, there are alternate interpretations of this data which will now be considered.

Alternate Interpretations of the Data

Slamecka (1968) has pointed out interpretations of the data which favour a frequency hypothesis. He has suggested that increases in organization may be interpreted as evidence for learning how to organize items in storage. However, it is also consistent with the interpretation that an S is learning to develop more efficient strategies for retrieval.Thus, the positive correlation between amount recalled and degree of organization may be an indication that systematic retrieval plans constitute relatively efficient search devices.

At first glance, this interpretation of the data does not seem to differ from an organizational interpretation. However, there is a major difference. Slamecka's interpretation suggests that the retrieval plan which is developed is sufficient to retrieve a series of independently stored items and that the items need not be arranged into cohesive groups. This suggests that the absolute retrieval capacity of memory can be increased. On the other hand, the organizational hypothesis suggests that retrieval, in view of the limited capacity of memory, can only be increased if items are arranged in storage into related groups that function as units in recall.

A frequency interpretation of the data, such as Slamecka's (1968), does not contradict the results of cued recall studies. It is possible that Ss may have stored more items than a recall trial indicates, but that some of these items are below recall threshold. Providing additional cues at the time of recall may lower the recall threshold of these items. Thus, frequency may function by increasing the recall strength of previously stored but unrecalled items, until they are above recall threshold. It need not necessarily lead to organization of the material into related units or groups.

Slamecka (1968) presented data which indicated that items may be stored independently or functionally isolated. Two groups of Ss, context and control groups, were presented a list of words. The context group then received half of the original list and were asked to recall the remaining words. The control group was not given this aid and were asked to recall all of the words. There was no differences between context and control groups in the recall of those words not originally given to the context group. Slamecka concluded that items directly accessible at recall did not change the probability of retrieving the rest of the items. He further suggested that part-to-whole transfer effects can be interpreted in light of independent storage. The retarding effect on second list learning for experimental Ss could be due to the necissity of devising a new retrieval plan. It might not be due to the necissity of reorganizing the stored items.

However, Slamecka's data and conclusions are applicable only to the single trial case, as he himself has pointed out. His context and

control groups were allowed only a single study trial on the list before the recall test. It is conceivable that item storage may be independent in single trial tasks but that multi-trial tasks do produce a state of organization of the stored items. Slamecka believes that such a discontinuity in the emergence of organization from single trial to multi-trial tasks is unlikely, if organization is the key to successful recall performance. However, Tulving and Osler(1967) have suggested that organizational processes play a relatively small role on the first learning trial, although they are responsible for trial to trial increments in recall. Therefore, it is, in fact likely that there might be a discontinuity in the emergence of organization from the first to the remaining learning trials.

The Present Investigations

One of the major distinctions then between an organizational and a frequency hypothesis is the question of whether multi-trial tasks do produce a state of organization of the stored items. The organizational hypothesis suggests that this is the case, while a frequency hypothesis suggests that it is not. Slamecka (1968) has already presented data which suggests that in single trial tasks items are stored independently of each other and that recall of one does not affect recall of the others. However, Tulving and Osler(1967) suggested that organizational processes play a relatively small role on the first learning trial.

The hypothesis that multi-trial tasks do produce a state of organization of the stored items and that this is responsible for

the repetition effect underlies an organizational interpretation of part-to-whole and whole-to-part transfer data. However, Slamecka's (1968) suggestion indicates that other interpretations are possible. Therefore, the experimental data, collected thus far, are open to alternate explanations. However, a more stringent test of the hypothesis, than previous experiments have provided is possible.

Investigating the effect of organizational incompatibility over trials, on recall performance, is a method of testing the hypotheses. Organizational incompatibility refers to those cases in which it is difficult for Ss to organize items into related groups during multi-trial tasks. Recall increments which can be demonstrated to proceed under conditions of organizational incompatibility, at the same rate as those under conditions of organizational compatibility, in multi-trial tasks, would suggest that the function of repetition is other than to produce a state of organization of the stored items (i.e. argue in favour of a frequency hypothesis). Experiment I was designed to examine a situation in which Ss would be faced with organizational incompatibility from trial to trial and to compare their recall performance to Ss not faced with such incompatibility.

It is difficult to know when organizational incompatibility exists from one trial to the next. However, consider an S presented with a list of words on trial N. Of these words, a number have been repeated from the previous trial N-1, and a number are novel words which have replaced the words not repeated from the previous trial. The fewer the number of repeated items from trial N-1, the greater

would be the probability that a repeated item formed part of an S-unit which is not repeated from trial N-1 to trial N. Thus, the greater would be the probability that the repeated item was organized into an S-unit which is incompatible for trial N. Therefore, according to the organizational hypothesis, the repeated word should be no more likely to be recalled on trial N, than it was on trial N-1.

Another approach to investigating the repetition effect is to eliminate any advantage that either frequency or organization might have on recall increments without eliminating the effect of the other. One way to eliminate any advantage of frequency without eliminating the effects of organization, would be to remove those items not recalled on each trial and replace them by novel items on the subsequent trial. Rock (1957) has previously used this drop out procedure in a paired-associate learning situation. If recall increments are observed, this would be evidence in favour of an organizational hypothesis, since this procedure should have no effect according to organizational theory.

Using the same procedure, but replacing recalled items instead of unrecalled items, can theoretically eliminate the effects of organization without eliminating the effects of frequency. However, this experimental manipulation makes it difficult to detect increments in recall since previously recalled items are deleted. Consequently, an analysis of the probability of recall of repeated versus non-repeated

items would be more appropriate in this situation than an analysis of trial to trial recall data. A frequency hypothesis would be supported if repeated words had a greater probability of being recalled than non-repeated words. If no significant differences were found between their probabilities of recall, an organizational interpretation of the data would be favoured. In order to evaluate these hypotheses, Experiments II and III were designed to investigate the effect of replacing recalled and unrecalled words on succeeding trials of a free recall learning task.

EXPERIMENT I

Method

Subjects

Ss were 36 male and female introductory psychology students from Lakehead University. Participation in experiments served as part of the course requirement.

Stimulus Material

Nine words (critical words) were repeated on four successive lists of words, each list totaling 27 words in length. Three groups of Ss differed as to the nature of the relationship between the successive lists.

For group 1, critical group (C), the critical words were the only words common to each of the four successive lists. For group 2, Critical plus 9 group (CP), the critical words and nine other words

were common to each successive list. For group 3, repetition group (R), all words including the critical words, were common to each of the successive lists.

Words were drawn in a random fashion from a pool of words having Thorndike and Lorge (1944) G count frequencies in the range of 40-49. The nine critical words were selected randomly from this pool.

A total of nine lists were then randomly constructed, each list contained 27 words. Two of these were practice lists and contained no words in common with each other, or the others. One was designated as List 1 and contained the critical words randomly combined with 18 additional words. Three of the remaining lists contained the critical words and nine others common to each other and List 1. The final three lists contained only the critical words common to each other and List 1.

Procedure

Ss were randomly assigned to one of three experimental groups. each group was composed of 12 Ss. All Ss in each group received first the two practice lists with a written recall trial after each. This was followed by List 1 and a recall trial.

For group 1 (C), List 1 was followed by the three lists on which only the nine critical words were repeated over each list. For group 2, (CP), List 1 was followed by the three lists on which the critical words and nine other words from List 1 were repeated over each list. For group 3 (R), List 1 was followed by three additional random presentation orders of List 1.

The words of each list were presented visually on white index

cards, hand printed in block letters. Their rate of presentation was one word every three seconds. Ss were allowed one minute at the end of each list for a written recall trial, which was indicated by a blank index card at the end of each list. The next list followed the recall trial immediately.

Upon arrival Ss were given six sheets of blank paper numbered 1-6. They were instructed that they would be presented six lists, each 27 words in length, one list at a time. They were told that at the end of each list was a blank index card and that when it appeared, they were to recall as many of the 27 words as possible, by writing them down on the appropriate sheet. A number of blank index cards were inserted at the end of each list. In this way, Ss could not estimate when the list was about to end and use this as a cue to rehearsal strategy. Ss were not instructed that the first two lists were practice lists. They were merely told to try to recall as many words as possible from each list.

Results and Discussion

Total Recall Performance

Although recall of the critical words was of primary interest in the present study, the total recall data was also examined. A repeated measures analysis of variance with three levels of groups and four levels of trials was performed on the total recall data. This analysis revealed a significant group effect (F 4.93, df 2,33, p .05), a significant trials effect (F 47.00, df 3,99, P .01), and a significant group by trials interaction (F 6.30, df 6,99, p .01).

The group means are represented graphically in Figure 1. The mean number of words recalled on trial 1 did not differ significantly between the three groups (Newman-Kuels). Thereafter, the groups begin to diverge as is evident from Figure 1. The mean number of words recalled on trial 2 by group CP (9.92) did not differ significantly from group C (9.50). However, on the remaining trials the mean number of words recalled differed significantly between all three groups.

Critical Word Recall Performance

A repeated measures analysis of variance with three levels of groups and four levels of trials was performed on the recall data of the critical words. There was no significant group effect or group by trials interaction. However, there was a significant trials effect (F 34.98,df 3,99, p .01). Figure 2 shows graphically the mean number of critical words recalled by each group on each of the four recall trials.

Since the group by trials interaction was not significant, it can be concluded that the experimental treatments did not affect recall of the critical words over the four trials. An organizational hypothesis would predict a significant interaction. The liklihood of a critical word being part of an inappropriate S-unit should differ for the three groups , as indicated earlier. According to this reasoning group R should show the greatest increments in recall of the critical words, group CP should occupy an intermediate position, and group C should display the smallest increments in recall.

It is difficult to expalin the non-significant interaction in terms of an organizational hypothesis. If the function of multi-

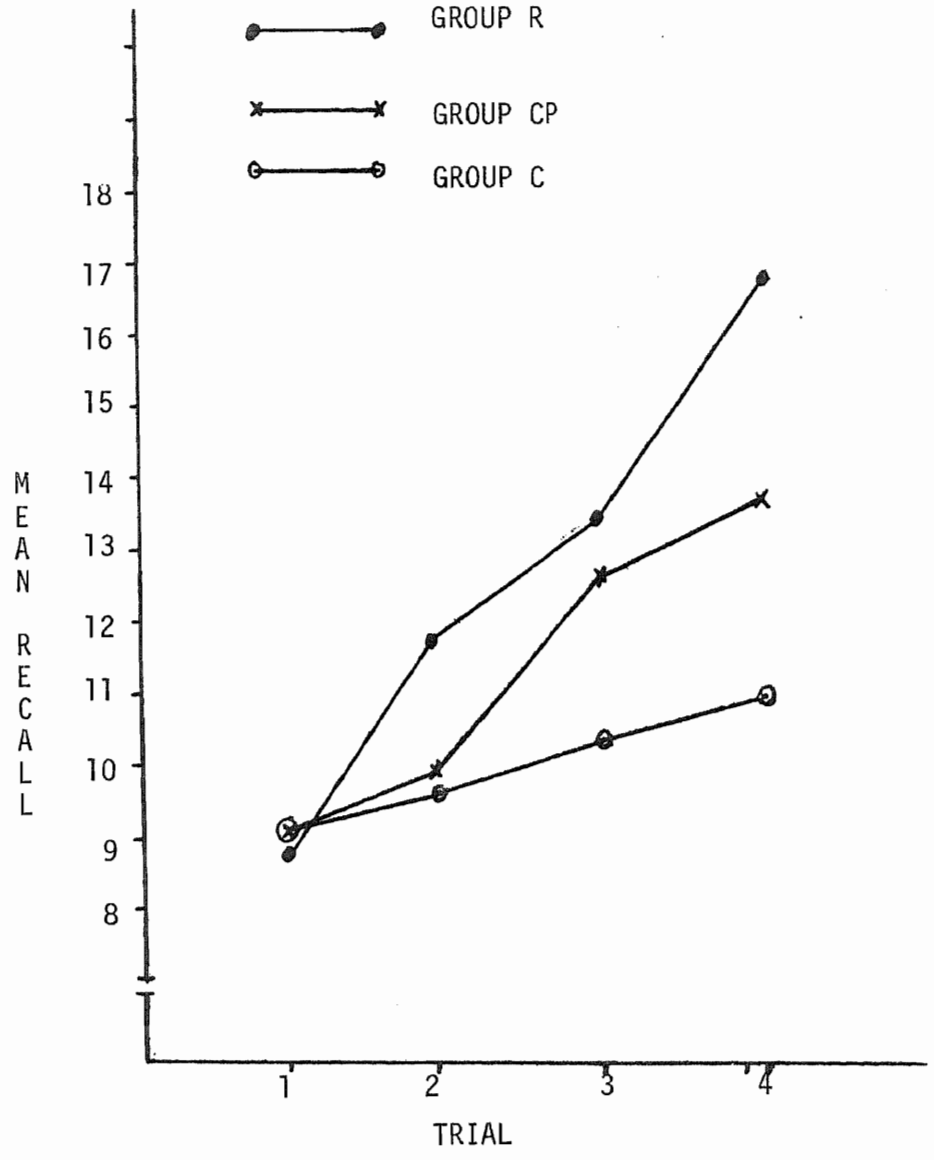

Figure 1 Mean Number of Words Recalled as a function of Trials for Each Group in Experiment I.

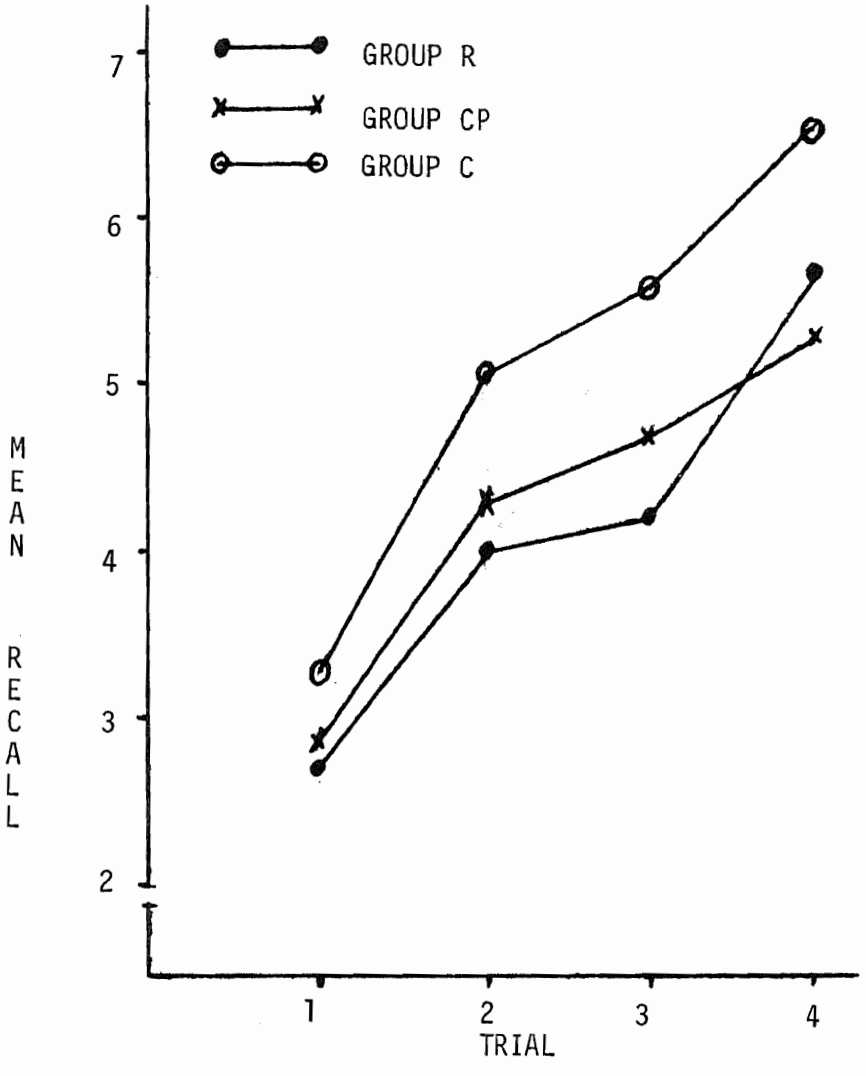

Figure 2 Mean Number of Critical Words Recalled as a Function of Trials for Each Group in Experiment I.

trial practice is to allow the development of interword dependencies of the stored items this task would be difficult for group C. However, although organizational incompatibility of the critical words was present from trial to trial for group C, this did not seem to affect recall of these words. It would seem that frequency had a direct facilitative effect on the recall of the critical words, independent of the organizational incompatibility that was present.

A further observation which suggested that no interword dependencies of the stored items was developed over trials was that for groups C and CP no previous list intrusions occurred for any S, on any of the final three recall protocols. If recall of the critical words depended upon organization of stored items into related groups, it would be expected that the organizational incompatibility present for these groups would have led to such intrusions.

EXPERIMENT II

Method

Subjects

Ss were 36 male and female introductory psychology students from Lakehead University. Participation in experiments served as part of the course requirement.

Stimulus Material

One hundred and twenty words were drawn in random fashion, from a pool of words having Thorndike and Lorge (1944) G count frequencies

in the range of 40-49. Six lists of 20 words each were constructed randomly from these 120 words. Two of these lists were designated as practice lists and one as experimental list 1 (E.L. 1).

Procedure

Ss were randomly assigned to one of three experimental groups, each composed of 12 Ss. All Ss were tested individually and were first presented the two practice lists, with a recall trial after each. These lists were in turn followed by E.L. 1.

The design was similar to the drop out procedure used by Rock (1957). For group 1, repetition group (R), E.L. 1 was followed by three additional random presentation orders of E.L. 1. For group 2, recalled repeated group (RR), E.L. 1 was followed by three lists, each composed of the items recalled correctly from the preceeding list with novel items substituted for the unrecalled items. For group 3, unrecalled repeated group (UR), E.L. 1 was followed by three lists, each composed of the items not recalled from the preceeding list, with novel items substituted for the recalled items. In all cases, all lists were composed of a total of 20 words.

The substitution procedure for groups RR and UR was as follows. Three lists of 20 words were already prepared in advance from the pool of 120 words. Also, three random presentation orders of the numbers 1-20 were prepared for each S. During recall of E.L. 1, E recorded the correctly recalled items by placing a check next to them. For group RR, the checked items were substituted into one of the three lists prepared in advance, in serial positions indicated by reading

down one of the random blocks of numbers 1-20. For group UR, the unchecked items were substituted in this way. This procedure was repeated in constructing lists three and four for both groups, using the remaining two advance prepared lists and random blocks on numbers.

Lists were read clearly and loudly by E at the rate of one word every two seconds. Ss were allowed a free recall period at the end of each list, which was terminated when 15 seconds elapsed without a response. The checking and replacement procedure took place out of view of Ss and the replacement procedure took about one minute. A similar task was performed by E for group R. Thus, there was a delay of one minute between the end of the recall trial and the beginning of the next list for all Ss.

All Ss were instructed that they would be read six successive lists of 20 words, one list at a time, with an oral recall trial after each. They were told to concentrate on each word as their task would be to recall as many of the 20 words as possible, in any order that they desired. No further instructions were given and Ss did not know that the initial two lists were practice lists.

Results and Discussion

A repeated measures analysis of variance with three levels of groups and four levels of trials was performed on the recall data. This analysis revealed a significant trials effect (F 29.51, df 3,99 p .01), and a significant group by trials interaction (F 4.65, df 6,99 p .01). The mean number of words recalled by each group on each of the four recall trials is shown graphically in Figure 1.

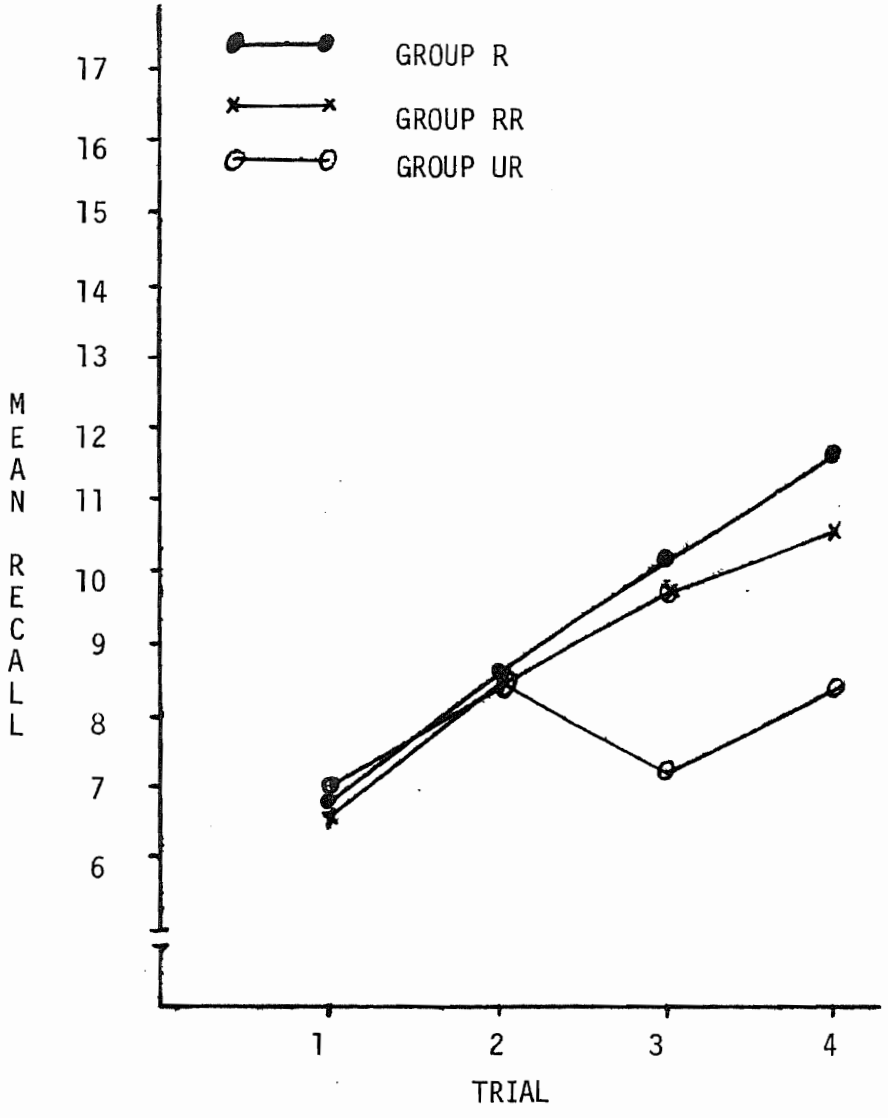

Figure 3 Mean Number of Words Recalled by Each Group on Each Trial in Experiment II.

The mean number of words recalled on trial 1 did not differ significantly between the three groups. Thus, any differences thereafter can be attributed to the experimental treatments. The group by trials interaction was examined using an F test for simple effects (Bruning and Kintz, 1968). This test revealed that the learning rates of groups R and RR did not differ from each other, over the four trials (F 0.42, df 3,99). Thus, the replacement of unrecalled items by novel items in group RR had no effect on rate of learning, as compared to group R in which all items from the previous list were repeated.

However, the learning rate of group UR was significantly lower than both group R (F 8.09, df 3,99, p .01) and group RR (F 5.44, df 3,99, p .01). Thus, the replacement of recalled items by novel items retarded the learning rate of group UR, as compared to the other two groups. Further analysis did reveal that there was a learning trend in group UR over the four trials (F 3.41, df 3,99, p .025). The fact that this group does show a learning trend over trials, indicates that when recalled items were removed and replaced by novel items, Ss still displayed increments in recall over trials.

The fact that groups R and RR showed the same learning rates argues in favour of an organizational hypothesis. As long as S-units developed on the previous trial remain intact Ss are capable of increments in recall, even when unrecalled items were replaced by novel items over trials. This suggests that frequency is not sufficient to explain increments in recall in free recall learning. the increments in recall observed for group RR cannot be attributed to

the fact that each repetition of an unrecalled item increased its recall probability and is thus responsible for increments in recall in this group.

The results of the present experiment are based on four recall trials. An inspection of Figure 3 shows that on recall trial 4 performance of group RR is below that of group R. The difference between the mean words recalled on trial 4 by group R (11.50) was not significantly different from group RR (10.50) (Newman-Kuels). However, there is the suggestion that perhaps the performance of group RR is reaching an asymptote of performance below that of group R.

The probability of recalling repeated and non-repeated words in group UR was evaluated in the following manner. For each of the 12 Ss in this group, the total number of repeated and non-repeated words on trials 2,3, and 4, were calculated. The proportion of correctly recalled repeated items and correctly recalled non-repeated items were then calculated for each S. These proportions were compared using the Willcoxon matched pairs sign rank test (Siegel,1956). It was found that the proportion of repeated words recalled was significantly greater than the proportion of non-repeated words recalled in this group (T 7.5, N 11, p .01). Thus, the repetition of unrecalled items in group UR does increase their probability of recall over that of non-repeated items.

This frequency effect observed in group UR also supports the suggestion that the performance of group RR might be reaching an asymptote of performance below that of group R. Thus, there is the possibility

that groups R and RR might begin to differ significantly on later trials. The replacement of unrecalled items for group RR might have an effect on their later learning performance. Experiment III which was essentially a replication of Experiment II was carried out to test this possibility. The experiment included an additional six trials, bringing the total to ten. List length was slightly reduced to allow for a greater pool of replacement words. Further, the data of Experiment II were collected in such a manner that organization in the recall of groups R and RR could not be compared. Experiment III allowed this comparison.

EXPERIMENT III

Method

Subjects

Ss were 24 male and female students drawn from the same source as Experiment II.

Stimulus Material

One hundred and ninety two words were drawn in random fashion from a pool of words having Thorndike and Lorge (1944) G count frequencies in the range of 30-49. This range was extended from that of Experiment II in order to have a larger pool of words. Twelve lists of 16 words each were constructed randomly from the pool. Two of these were designated as practice lists and one as experimental list 1 (E.L. 1).

Procedure

Ss were randomly assigned to one of three groups of eight Ss each.

The only difference in procedure from Experiment II was that E.L. 1 was followed by nine additional lists for each group. Recall was also numbered in the order of recall, rather than just checked, so that organization could be measured later.

Instructions were changed only in that Ss were told that they would be presented 12 successive lists of 16 words each. All other instructions were exactly as in Experiment II.

Results and Discussion

A repeated measures analysis of variance with three levels of groups and ten levels of trials was performed on the recall data. This analysis revealed a significant group effect (F 7.60, df 2,21 p .01), a significant trials effect (F 10.67, df 9,189, p .01), and a significant group by trials interaction (F 2.44, df 9,189, p .01). Figure 4 shows graphically the mean number of words recalled by each group on each of the ten recall trials.

The mean number of words recalled on trial 1 did not differ significantly between the three groups. Any differences thereafter can be attributed to the experimental treatments.

The group by trials interaction was further examined using an F test for simple effects (Bruning and Kintz, 1968). This test revealed that the learning rates of groups R and RR did not differ significantly from each other (F 1.42, df9,189). Thus, the replacement of unrecalled items by novel items in group RR had no effect on rate of learning over the ten trials, as compared to group R in which all items were repeated. Further, the learning rate of group UR differed

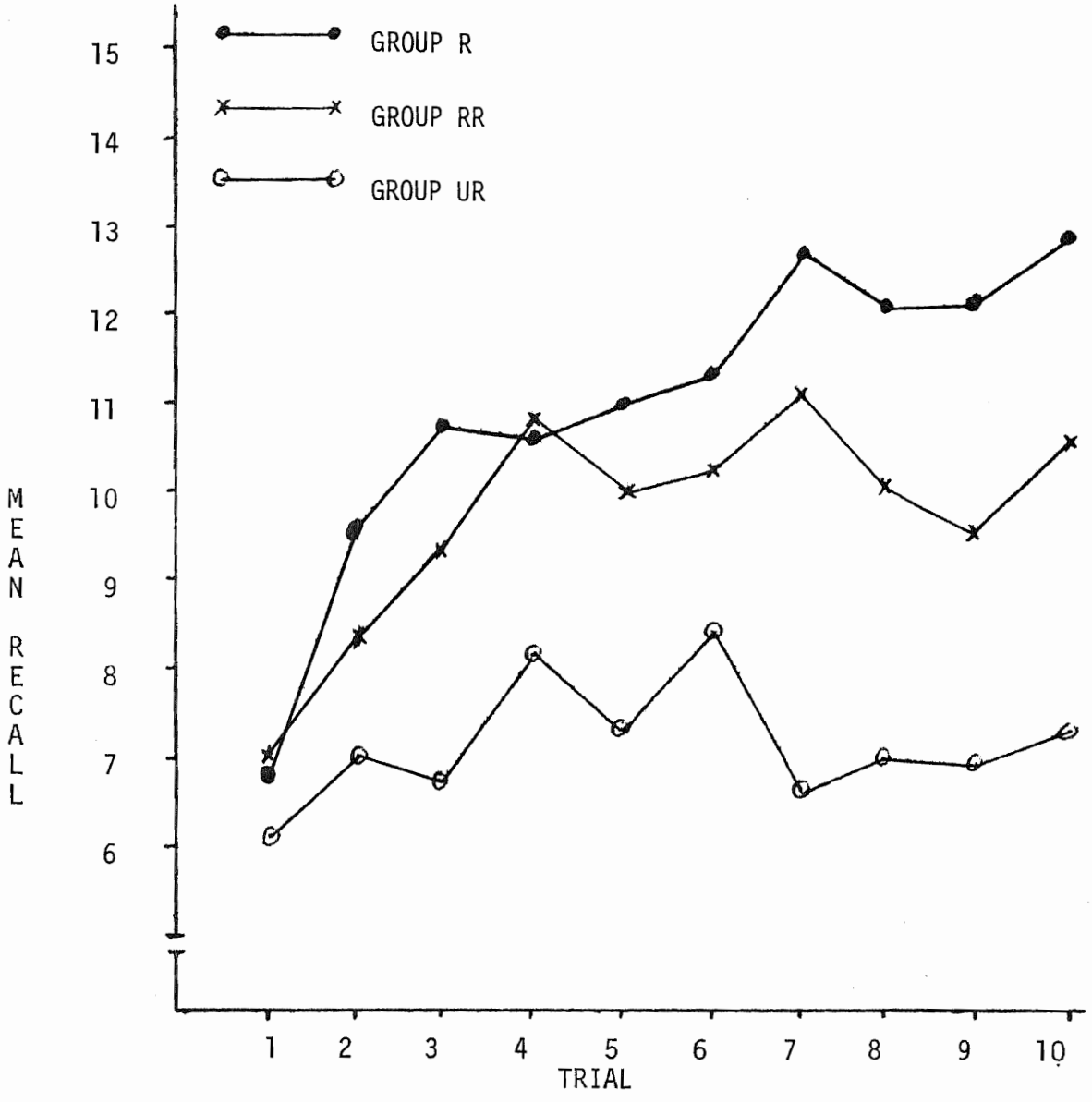

Figure 4 Mean Number of Words Recalled as a Function of Trials for Each Group in Experiment III.

from that of group R (F 6.05, df 9,189, p .01). Thus, the replacement of recalled items by novel items retarded the learning rate of group UR as compared to group R. Group UR showed no significant learning trend over the ten trials of the experiment (F 1.33, df 9,189).

The separation of groups R and RR noted in Experiment II on trial 4, is also apparent in Experiment III. An inspection of Figure 4 shows that after trial 5 the recall performance of group RR was consistently below that of group R. However, the mean number of words recalled by group RR was significantly below that for group R only on trial 9.

The probability of recalling repeated and non-repeated words in group UR was examined in the same manner as Experiment II. This analysis revealed that the probability of recalling repeated and non-repeated words did not differ significantly in this group (T 3, N 7). Thus, no frequency effect was apparent in this experiment.

Subjective organization of recall on trials 1-6 for groups R and RR was evaluated in terms of the intertrial repetition measure described by Bousfield and Bousfield (1966) and used by Tulving and Osler (1967). This measure represents the difference between the number of obtained intertrial repetitions of ordered pairs (O.I.T.R.) and the number of such repetitions expected by chance (E.I.T.R.). This analysis cannot be used with group UR, since all recalled items from the previous trial were replaced by novel items.

For each S in groups R and RR, a mean I.T.R. measure was found by summing his I.T.R. scores over the first five pairs of successive trials (trials 1 and 2, 2 and 3, 3....., and 5 and 6) and then dividing by the

number of pairs of trials (Tulving and Osler, 1967). An analysis of variance performed on the 16 I.T.R. scores thus obtained proved to be non-significant. Thus, Ss in groups R and RR organized the material at the same level, over the first six trials of the experiment.

GENERAL DISCUSSION

The purpose of the present series of experiemnts was to clarify the relative importance of both frequency and organization as sufficient explanations of the repetition effect. In general, the results suggest that both processes are important in determining the increments in recall.

The results of Experiment I support a frequency hypothesis. Organizational incompatibility of the critical words over trials was present in group CP and to an even greater extent in group C, as compared to group R. Thus, the critical words should have been harder to organize into related units over trials for group C as compared to group CP and R, and for group CP, as compared to group R. However, recall of the critical words did not differ between the three groups.

Slamecka (1968) has demonstrated that items are stored independently of one another in single trial tasks and has suggested that this may also be the case in multi-trial tasks. The fact that increments in recall of the critical words did not differ between the three groups of Experiment I supports this suggestion. The organizational incompatibility of the critical words, present in groups C and CP,

did not affect their recall, although this would make it difficult to organize them into related units. Therefore, the results argue against the hypothesis that multi-trial tasks produce a state of organization of stored items. They thus contradict one of the basic assumptions of the organizational hypothesis, that repetition is effective only if it allows organization of material into related units or groups.

Experiment II provides further data which suggests that frequency has a direct facilitative effect on recall, independent of organization. The probability of recalling repeated words was significantly greater than that of non-repeated words, in group UR of this experiment. In this group, increases in the probability of recalling repeated words cannot be due to the benefit of previous organization. Recalled words and therefore, existing S-units, were deleted on each succeeding trial. Thus, the increases in the probability of recall of repeated words is acheived through their sheer frequency of presentation. Although a similar result was not found for group UR of Experiment III, the difference, again in the same direction, did approach significance.

However, the remaining data of Experiments II and III support an organizational hypothesis. The fact that group RR showed a similar learning rate to that of group R indicates that Ss are still capable of increments in recall, even though unrecalled items are replaced with novel items.

A frequency hypothesis is not capable of explaining this find-

ing. The Ss in this group could not have benefited from the frequency of repetition of unrecalled items, since such items were removed on each trial and replaced. Therefore, the increments observed in group R of these experiments, is not due to the repetition of unrecalled items.

An organizational hypothesis, however, is capable of explaining the increments in recall observed for group RR. Since recalled items were not removed, it can be concluded that the S-units which Ss develpoed on previous trials remained intact on successive trials. Since only unrecalled items were removed and these were not part of the existing S-units (Tulving and Osler,1967), this procedure should have no disruptive effect on the organizational process. Therefore, the increments in recall over trials observed in group RR, could be due to the novel words being incorporated into existing S-units.

The implication that increments in recall in group RR result from organizational processes suggests that items are added to S-units in an all-or-none manner rather than an incremental manner. It was no more difficult for Ss in group RR to incorporate novel items into the existing S-units than it was for Ss in group R to incorporate the repeated items.

In summary, the results of the present investigation, taken together, support both hypotheses. Ss are capable of utilizing only frequency to increase recall if organizational factors are not available (Experiment I). On the other hand, they are also capable of

utilizing only organization if frequency factors are not available (Experiments II and III). Thus, both frequency and organization are important in determining recall increments. Neither hypothesis alone is adequate to explain all the results of the present investigation.

Recently, Slamecka, Moore and Carey (1972) have also suggested that neither simple organization or simple frequency alone were sufficient to explain part-to-whole transfer effects and that an S's "emmission criterion" must be recognized. Slamecka et. al. suggested that there was uncertainty on the part of experimental Ss in part-to-whole transfer, as to whether all or only some items are being repeated from the previous list. Due to this uncertainty, and his desire to recall correctly, an S may raise his overall emission standard and settle into a higher criterion attitude of responding throughout the transfer task trials. When experimental Ss were given instructions designed to lower their overall criterion, positive transfer was obtained in part-to-whole transfer. Also, Wood and Clark (1969) have demonstrated that by simply instructing experimental Ss about the relationship between the two lists in part-to-whole transfer, their performance was much improved over that of control Ss.

In conclusion, the process of free recall appears to be more complex than anticipated by previous research. A variety of experimental conditions have been demonstrated to affect recall of material in multi-trial tasks. The results obtained in some studies, can be changed, to the point of reversal, by simple instructions

to the S. No existing theory, either frequency or organization, seems adequate to incompass the many task variables which have been shown to influence the recall of material in multi-trial tasks. Any theory which attempts to do this, must account for the variety of situations in which recall increments have been displayed, including those of the present investigation.

SUMMARY AND CONCLUSIONS

The present research consists of three experiments designed to assess the importance of organizational and frequency factors in determining recall increments in multi-trial free recall learning.

The results of Experiment I indicated that recall of nine critical words over four trials was not affected by the number of accompanying repeated words and thus argued in favour of a frequency hypoyjesis. However, the results of Experiments II and III indicated that replacing unrecalled words by novel words over trials did not affect learning rate as compared to the typical multi-trial learning situation. These results were interpreted in favour of an organizational hypothesis, since frequency is not able to explain these similar learning rates.

It was concluded that neither frequency nor organization were sufficient to account for recall increments in multi-trial free recall learning and that the process of free recall was more complex than anticipated by previous research.

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APPENDIX

EXPERIMENT I

TABLE I

Analysis of Variance Summary
for Total Recall Data.

SOURCE	DF	SS	MS	F
Groups	2	190.266	95.133	4.934*
ERROR	33	636.293	19.282	
TRIALS	3	475.059	158.353	47.001**
TRIALSXGROUPS	6	127.398	21.223	6.302**
ERROR	99	333.543	3.369	

* $p < .05$
** $p < .01$

EXPERIMENT I

TABLE II

Analysis of Variance Summary Table for Critical Word Recall Data

SOURCE	DF	SS	MS	F
GROUPS	2	17.055	8.527	2.303
ERROR	33	122.188	3.703	
TRIALS	3	158.910	52.970	34.984**
TRIALS X GROUPS	6	3.944	0.657	0.434
ERROR	99	149.896	1.514	

** $P < .01$

EXPERIMENT II

TABLE III

Analysis of Variance Summary
Table for Total Recall Data

SOURCE	DF	SS	MS	F
GROUPS	2	59.289	29.645	1.661
ERROR	33	588.961	17.847	
TRIALS	3	211.914	70.638	29.153**
TRIALS X GROUPS	6	67.707	11.285	4.657**
ERROR	99	239.879	2.423	

** $p < .01$

EXPERIMENT III

TABLE IV

Analysis of Variance Summary
Table for Total Recall Data

SOURCE	DF	SS	MS	F
GROUPS	2	612. 098	306.049	7.604**
ERROR	21	845.230	40.249	
TRIALS	9	260.672	28.964	10.668**
TRIALS X GROUPS	18	119.320	6.629	2.442**
ERROR	189	513.145	2.715	

** $p < .01$

EXPERIMENT III

TABLE V

Analysis of Variance Summary Table
for Organizational Data of Groups R and RR.

SOURCE	DF	SS	MS	F
GROUPS	1	1.600	1.600	2.238
ERROR	14	10.010	0.715	